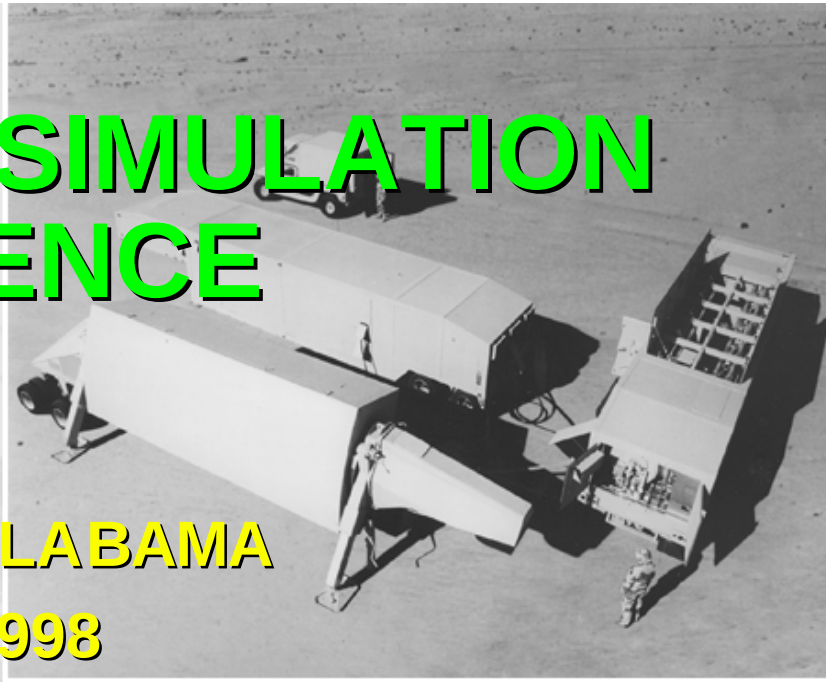

MODELING AND SIMULATION CONFERENCE

HUNTSVILLE, ALABAMA

MAY 13, 1998

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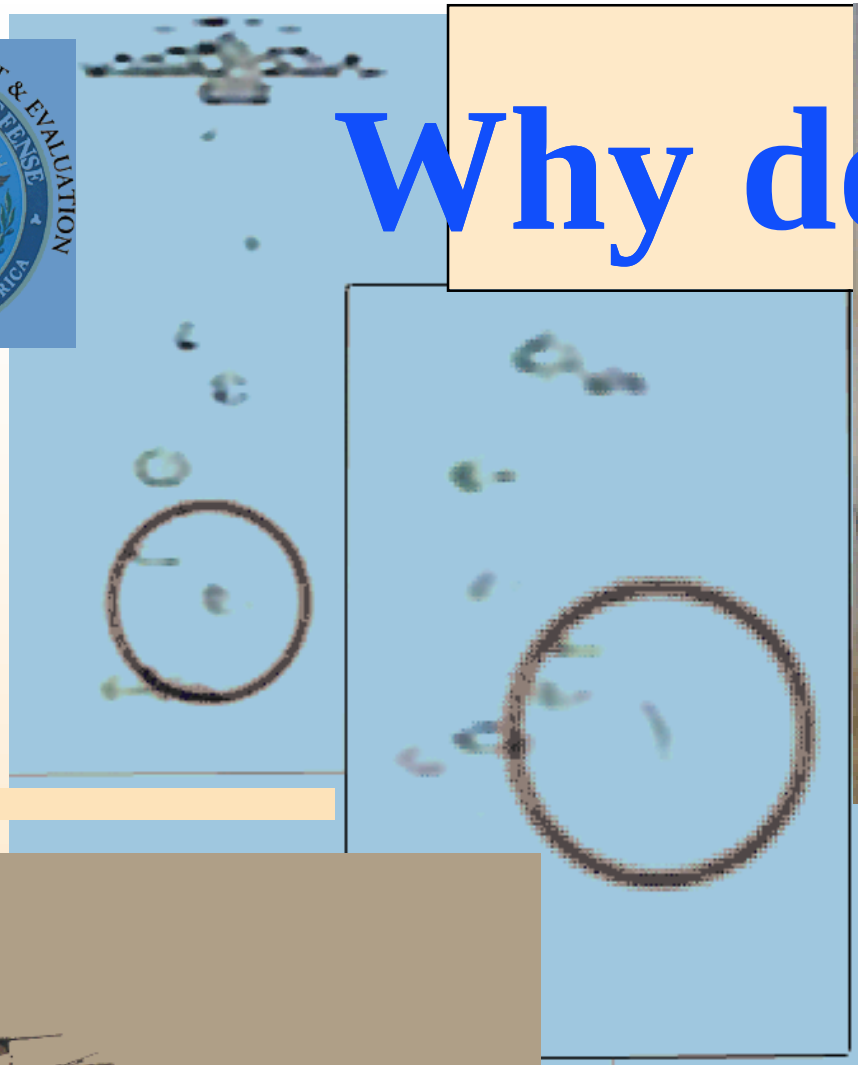
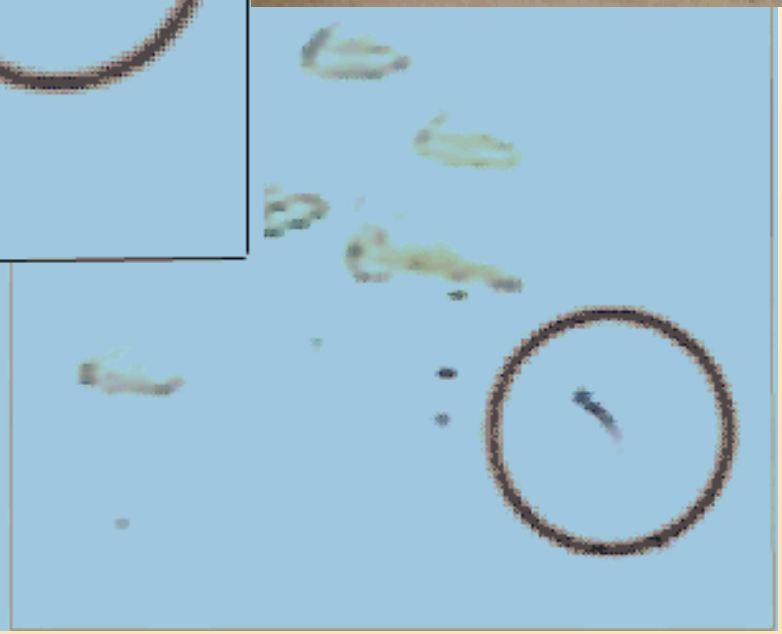
HUNTSVILLE CONFERENCE OBJECTIVES

- Common perspectives
- Exploit M&S potential
- Continue Dialogue
- Provide updated views on how the other services are embracing M&S
- Hear from PEO's about Progress and Impediments
- Emphasize your role

Why do M&S?





M&S Could Have Predicted This!

“Costly new vehicle found to roll over at intended speeds.”

New York Newsday
May 1, 1998

MYTHS

- Operational testers won't use M&S
- M&S is cheap
- Testing and M&S are opposite ends of a balance scale

TRUTH IS: M&S and testing are intertwined; when they are not, neither is effective

THE RATIONALE

Gain Early Understanding in Order to:

- Identify problems early
- Smooth transition between phases
- Achieve long-term savings
- Reduce cycle time

"M&S early in a program can be compared to a Warfighter's preparation for the deep battle."

CRADLE TO GRAVE APPLICATION

- Combat development
- Engineering and manufacturing development
- Test and evaluation
- Training
- Sustainment

Modeling & Simulation

MOD/SIM CHARACTERISTICS

- Appropriate Realism (resolution) - more is not necessarily better
- Physics based (fundamental) - often called first principles modeling (which is a misnomer)
- Predictive - implies understanding of required and possible accuracy
  - Quantifiable Error

Do what you have been doing better

Do what otherwise could not have been done at all

- TMD/NMD
- Life Cycle impact of RAM

EXAMPLES

- **Predator (requirements refinement)**
- **Sealift (design)**
- **C-17 (design, TTPs)**
- **THAAD (test planning)**
- **F-22 (live fire simulation)**

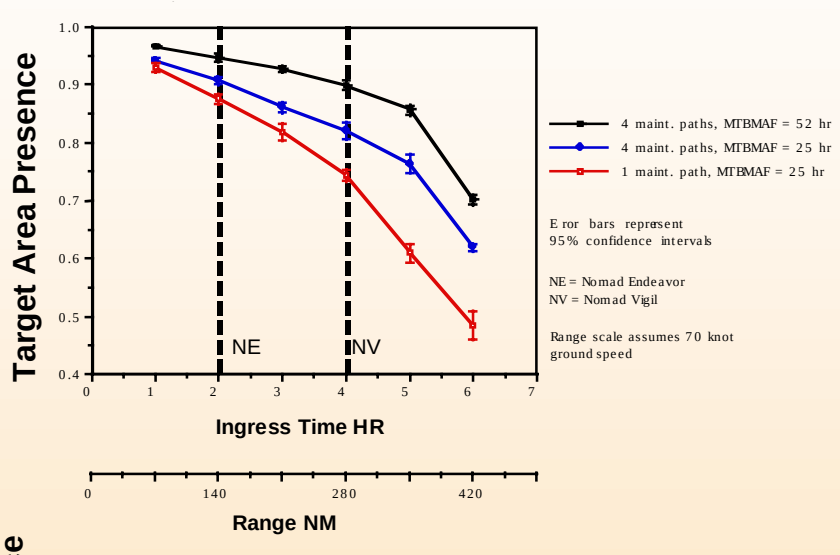
PREDATOR
(REQUIREMENTS REFINEMENT)

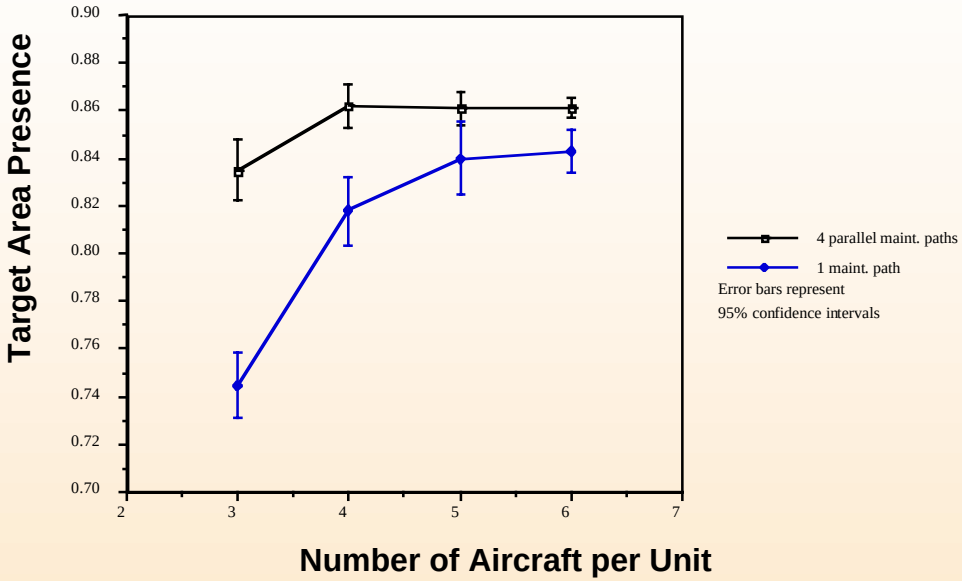
BACKGROUND AND MOTIVATION

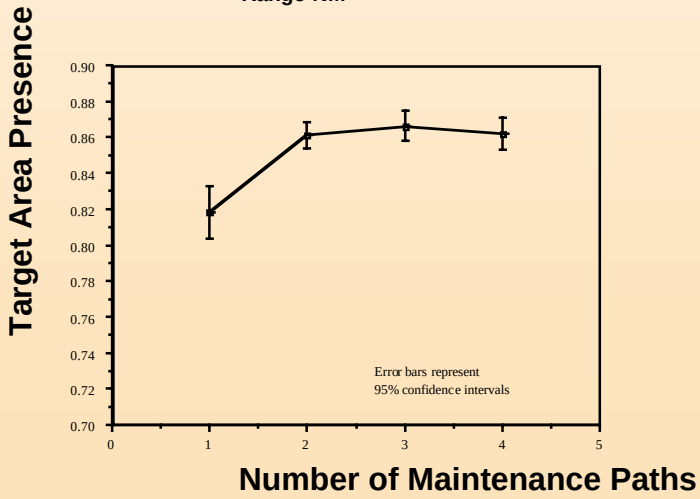
- **"Presence" Key Performance Parameter (KPP)**
  - **"The baseline MAE UAV system must be capable of continuous (with on-station relief) 24 hour intelligence coverage of any target in the operating area."**

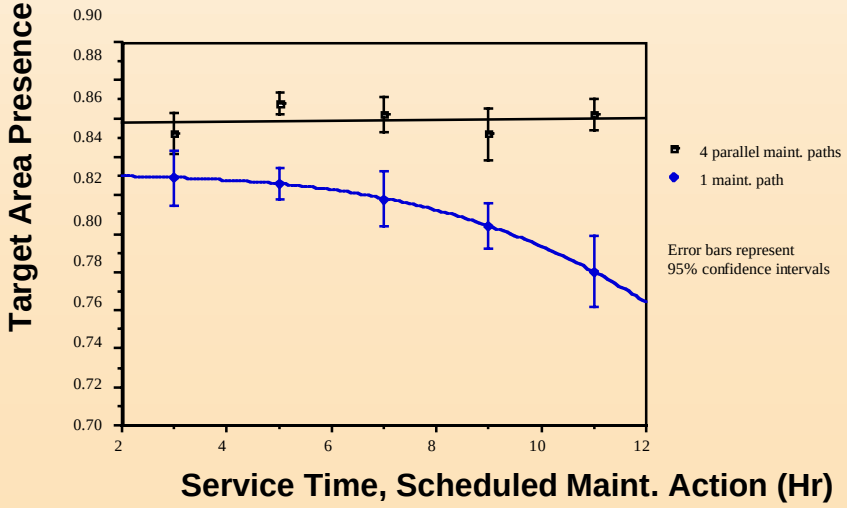
- **Continuous target area coverage never before attempted with Predator**
  - **have not demonstrated simultaneous control of multiple air vehicles**
  - **no typical operating range has been defined (CONOPS)**

TARGET AREA PRESENCE









PROGRAM IMPACT

- The simulation showed that ORD requirements would not be met by meeting technical specifications
- In addition, the simulation provided many insights for use in test planning and scoring

ON GOING WORK

- **Develop Military Aircraft Sustainability Simulation - (MASS)**
- **Looking at**
  - **Predator**
  - **High Altitude Endurance UAVs**
  - **E-6B TACAMO (In Progress)**
  - **JSTARS Platform Endurance**

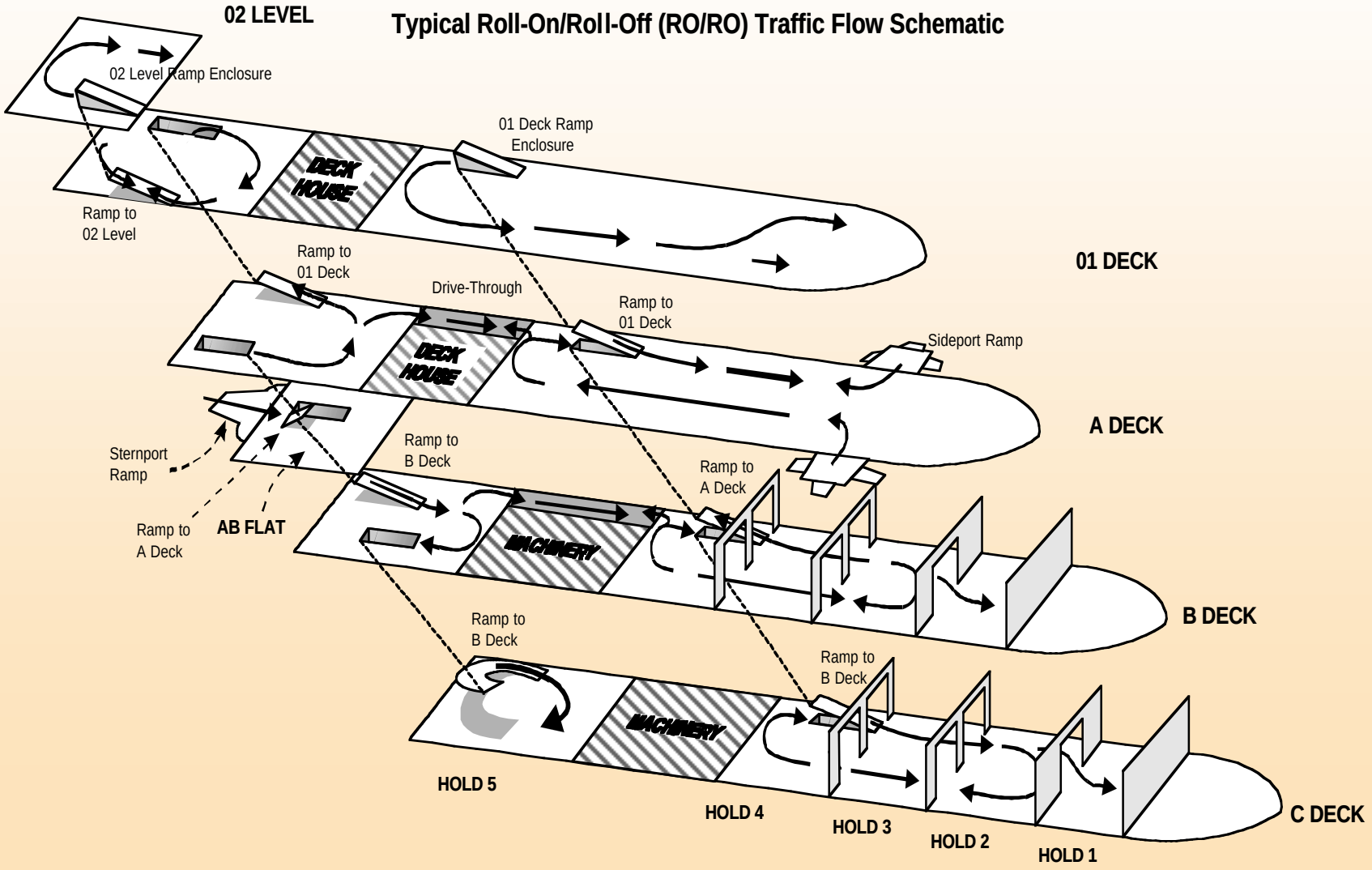
STRATEGIC SEALIFT
(M&S IN DESIGN)

STRATEGIC SEALIFT RATE MODEL REQUIREMENT

The material developer needed to accomplish the following tasks in support of the Strategic Sealift Acquisition Program:

- **Evaluate the cargo loading capability of proposed RO/RO ship designs for new construction and the conversion of existing ships;**
- **Estimate the load performance (loading rate in pieces and square feet per hour) of the Strategic Sealift ships using operational loading criteria; and**
- **Evaluate the ability of the designs to meet the 96 hour on-load/off-load requirement established by the Strategic Sealift operational requirements document (ORD).**

STRATEGIC SEALIFT SHIP DESIGN AND LOADING CHARACTERISTICS



CURRENT STATUS

Good progress using simulation, but tests still reveal problems

- **The USNS Watson Mission Critical Parameter Verification Test revealed that a ten ton ammo truck (M-977) could not make one of the turns on B Deck.**

C-17 AIRLIFT AIRCRAFT

BACKGROUND & MOTIVATION

- **USA Strategic Brigade Airdrop Mission**
  - **Rapid delivery of paratroops and heavy equipment to a distant conflict. Mission performed by C-141**
- **Deficiencies discovered in C-17 IOT&E**
  - **Paratrooper entanglement/interference**
  - **Turbulent air under C-17 tail and wake vortices**
  - **Attempted fixes included reduced airspeed, changed flap settings, deck angle modification**

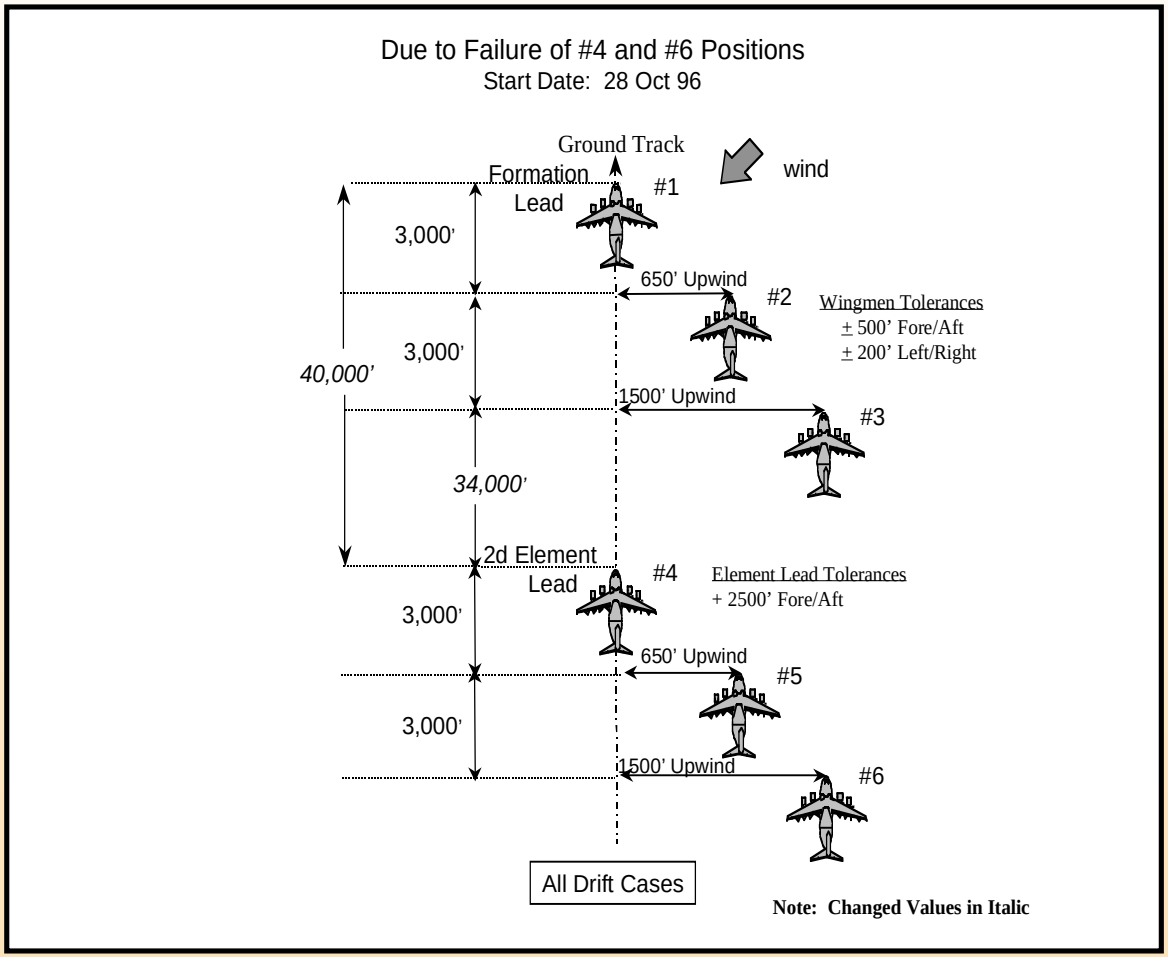
ADM: #1 PRIORITY IN FOT&E

- **Flow field turbulence and convergence behind C-17 increase entanglement risk**
  - **Limit airdrop options and configurations**
  - **Not identified in wind tunnel**
- **Wake vortices upset/collapse parachute**
  - **Vortices dictate new airdrop formations**
  - **Within- and between- element spacing**
  - **Initially inadequate data and models**

C-17 VORTICES

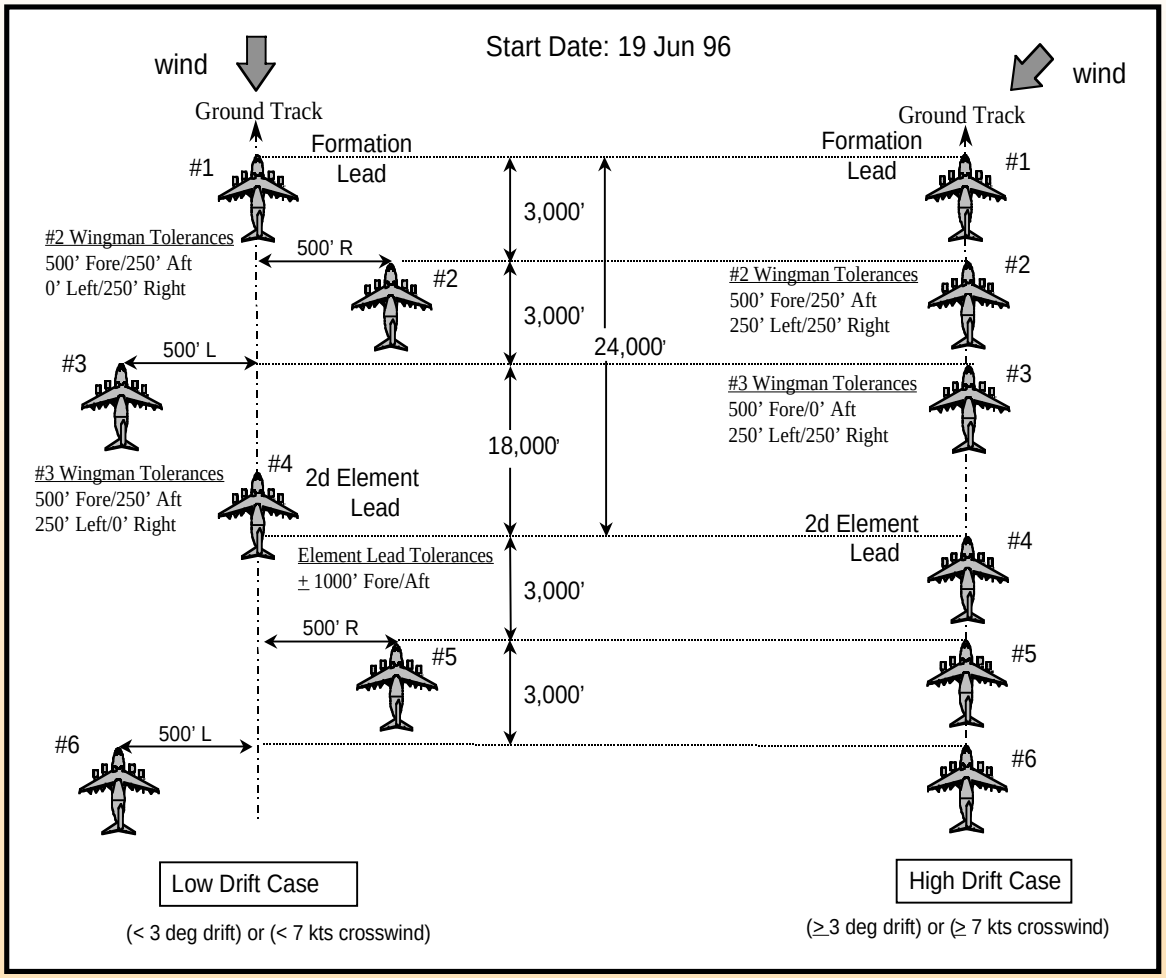
C-17 PERSONNEL FORMATION AIRDROP GEOMETRY

REVISION 4



C-17 PERSONNEL FORMATION AIRDROP GEOMETRY

REVISION 0



SIMULATIONS STILL EVOLVING

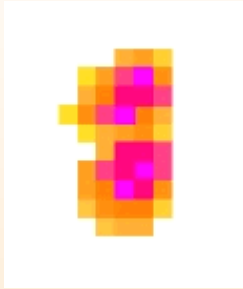
- Theory without data at the outset
- Computer simulation at Wright Labs
  - Strength and persistence “guesstimates”
  - Parachute trajectories not realistic
- LIDAR measurements yield some data
- Enhanced simulation started at AFIT
  - “Slices” of the vortex tubes modeled
  - USA help with parachute trajectories

THAAD HIT-TO-KILL

- One challenge is to identify where you want to hit, and guide to that point using:
  - Radar information
  - *A priori* knowledge
  - Target image
- Determine the orientation of the target in the image with time to guide to the “sweet spot”

TARGET IMAGES (EARLY)

- **Early End Game: - only long axis identifiable**



- **Later - nose and tail distinguishable**

Simulated Images (no background)

TARGET IMAGES (LATE)

- Last chance for a nose-tail change in aimpoint

- Last Image before target expands beyond field of view

Simulated Images (no background)

THAAD
ONGOING WORK

Add backgrounds to Images

Consider targets with fins

Analytic models and digital and hardware in the loop simulations are looking ahead to Flight-09 and Flight-10

Boeing F-22
Live Fire Test Evaluation

Pre-test Prediction

Test Produced Unexpected Damage

Test Conditions Reconciled with Model

Good Post-test Agreement

F-22 Live Fire Test Coverage

Live Fire Test 4, F-22 Test Article

Live Fire Test 4, F-22 Analysis Model

Top Panel

Live Fire Test 4, F-22
Event in Progress

Live Fire Test 4, F-22
Damage to Keelson

Live Fire Test 4, F-22
Damage to Keelson

Live Fire Test 4, F-22 Conclusions

- **Pre-test analysis was used to design the experiment**
  - assisted in shot-line selection
  - allowed omission of aft boom from test saving $100K + time
- **Post-test analysis**
  - demonstrated capability to predict extent of damage
  - predicted impulse within 5% best - 30% worst
- **Insights gained in the process**
  - analysis tools are capable of evaluating hydrodynamic ram events in complex structures.
  - the behavior of the fuel tank is sensitive to the boundary conditions

How do the real world boundary conditions compare to the modeled and tested condition ?

Don't Worry So Much About VV&A

- Focus on why, not just how M&S is being used
- Traditional VV&A works best for interpolation
- In research and testing, we are often extrapolating
  - In these cases VV&A comes with repeated use
- "Unaccredited" models can produce great insights

WHAT NEEDS TO BE DONE!

- Earlier involvement
- M&S in IPTs
- TEMPS that pay close attention to how M&S is used:
  - OT&E and LFT&E will be planned with models
  - Pre-test predictions and test data will be reconciled
- CAD/CAM to vulnerability model links
- OT&E events planned and predictive with model runs
- Continuously improve models with test results

Budgets for M&S

STRONG DOT&E SUPPORT FOR M&S

- My own experience
- Simulation Test and Evaluation Process
- Critical to future success
- Integrating M&S and T&E

UNDERSTANDING: INSIGHT NOT OVERSIGHT